Iowa DNR Flood Plain Issues
February 2009

Issue #1: *The so-called 100 year flood has become the de facto standard for floodplain regulations and protection. Larger floods can and do occur with some regularity. Should a higher standard be required and if so, what should it be?*

The consensus of the panel was that a flood larger than the 100 year flood should be used as the base flood for floodplain management purposes. After discussion of the pros and cons of various suggestions as to what that higher standard should be, the general agreement was that it should be the 0.002 percent exceedance probability year flood – the 500 year recurrence interval flood. A 500 year flood is by no means the largest flood reasonably possible but there was no support for using a Standard Project or Probable Maximum Flood as the base flood for floodplain management purposes.

There was also a suggestion the term "500 year flood" not be used to describe this flood; that alternative terminology such as "standard design flood" be used to avoid the misinterpretation associated with recurrence intervals. There was no consensus on what exactly that term should be and this will require some additional consideration. The Corps formerly used the term "Intermediate Regional Flood" to designate what was generally considered to be the 1% exceedance flood and something of this nature might be appropriate.

There are a number of arguments that can be offered in support of a higher standard.

- The 100 year flood is only an intermediate-sized flood. A building "floodproofed" to the 100 year standard has a 26 percent chance of sustaining some degree of flood damage during a 30-year period. And a house or business just marginally outside the 100 year floodplain would also have about a one-in-four chance of flooding in the same 30-year period.
- Floods much larger than the 100 year flood can and do occur with some regularity. Experience shows that the estimated 100 year flood discharge has been exceeded by a factor of four (Q_{100} x 4) in some locations.
- The current 100 year standard is not based on any cost-benefit analysis. It was, instead, more of a seat-of-the-pants recommendation intended to balance the need to control flood losses with the need to avoid overly stringent requirements that would be subject to political and property rights (due process and "takings") challenges.
- Conformance with the 100 year standard will not necessarily reduce flood losses statewide. A 1975 FEMA study (Schaeffer and Roland) showed that while compliance with 100 year standard would significantly reduce the rate at which flood losses would be expected to increase compared to a "no-regulation" scenario, flood losses across the nation would still continue to increase. The problem is that under the 100 year standard scenario, additional floodplain development would take place that still has some residual flood risk, thereby increasing the total risk. Only by imposing more stringent requirements would flood losses actually decrease.
- There is a significant degree of uncertainty associated with determining the magnitude of the 100 year flood discharge; the "true" 100 year flood could actually be considerably higher (or lower) than the estimate derived using the best contemporary methodology. Examination of the confidence limits for a number of the longer-term gaging stations shows the computed 500 year discharge is relatively close to the 95th percentile confidence limit for the 100 year discharge. Using a 500 year flood might be considered an "error on the conservative side" approach somewhat equivalent to using the 95th percentile confidence limit for the 100 year flood.
- Climate change could result in larger and more frequent floods. Calculation of the 100 and other recurrence interval floods assume stationarity – an assumption that what has happened in the past is indicative of what will happen in the future. Although there is presently no evidence of a statewide, long-term increasing trend in annual flood peaks in Iowa, climate change could potentially cause future floods to be higher and more frequent than what might be predicted based on an analysis of the historic record. Today's 500 year flood could be the 25, 50 or 100 year flood of the future. Thus, using "today's" 500

year flood might be considered a safety factor that recognizes the uncertainty of the future.

The panel acknowledged there could be significant hurdles and obstacles to implementing a 500 year standard. These include the following:

- Political resistance and legal challenges. Adopting a 500 year standard would be an administratively easy task – something that would only require a change in state administrative rules that could be done in six months or less. The initial resistance would likely be of a political nature – resistance to imposing more stringent standards on floodplain landowners. Even if the change were successfully adopted and implemented, there may be later legal challenges. The courts have almost universally upheld a 100 year standard as a reasonable standard; the court's potential reaction to a 500 year standards is unknown as there isn't any applicable case law.
- Lack of 500 year flood information. Many of the current flood maps only show the 100 year floodplain; 500 year flood information is not available for many locations. And FEMA increasingly is only determining 100 year flood levels even in detailed flood studies. Many of the future detailed study maps will only show the 100 year floodplain unless there is a change in policy.
- Map confusion. There likely will be a "two map" situation that might further confuse the general public. The NFIP-mandated flood insurance purchase requirement will in all likelihood continue to be tied to the 100 year floodplain and it will be necessary to continue to publish maps showing the 100 year floodplain. A second set of maps, FEMA-published or not, would also be required to establish the regulatory floodplain. A homeowner's lending agent might determine the homeowner does not have to purchase flood insurance because the lender's map shows the property is outside the "floodplain" but the city's map might show it to be within the floodplain subject to permit and elevation requirements.
- Existing development in conformance with the 100 year standard would have to be dealt with fairly, possibly by "grandfathering". Development done in full compliance with the existing 100 year standard would be considered "non-conforming" uses under a 500 year standard. A house protected to a 100 year standard that was substantially damaged by a much larger flood might be required to meet the 500 year standard to rebuild, which could be very difficult and costly. There's also the issue of whether the increased cost of compliance would be covered by a flood insurance policy with such coverage since the 500 year standard is not a NFIP requirement. Some type of grandfathering language might be possible but could be hard to develop and enforce equitably.

If Iowa, as some have proposed, is to develop and implement a floodplain mapping plan, it would be ideal to have the 500 year standard in place prior to the initiation of that effort so that the 500 year and other floods can be integrated into that effort. Whether FEMA would be amenable to including the 500 year or other floods like the Standard Project Flood on their official maps is not known, but it would be well to have that discussion with FEMA well before the mapping effort begins.

Issue #2: *Should critical infrastructure such as power plants, water treatment facilities, hospitals, main highways and public record repositories be required to be protected to the standard project, regional, or probable maximum flood level?*

The consensus of the panel was that some public facilities and infrastructure are so critical that the highest level of protection is warranted to insure such facilities remain operable under the most extreme levels of flooding considered reasonably possible.

Iowa's current level-of-protection requirements are summarized below:

- Moderate damage potential (seasonal residences, businesses and industries with readily-removable goods) – Q_{50} elevation (Note: under the NFIP, all "buildings" must be protected to the Q_{100} elevation)
- High damage potential (houses, most businesses and industries) – Q_{100} elevation plus one foot
- Maximum damage potential (hospitals, buildings containing documents, data or instruments of great public value, buildings with dangerous material or fuel storage facilities, power installations needed in emergency situations) – Q_{500} plus one foot.
- Low damage potential (all other uses) – no protection requirement.

Public facilities like water and wastewater treatment facilities only have to be protected to the Q_{100} elevation plus one foot. (Note: Under the NFIP, flood protection requirements only apply to buildings and their contents; any pumps, equipment, etc. that are not within a building have no protection requirements as they are not insurable unless they are within a building.) Bridges must have 3 ft. of clearance above the Q_{50} elevation but there are no specific requirements for the minimum level of protection for road grades (some road grades are purposely left low to provide for overflow to "save the bridge" during extreme events and to minimize upstream increases in flood levels).

The floods of '08 and '03 as well as a number of other less-noticed floods in recent years have provided graphic evidence that the 100 year flood is only an intermediate-sized flood and when a larger flood inevitably occurs, a number of critical public facilities become non-operable, with some sustaining significant damage that keeps them out of operation for a significant length of time.

If the 500 year flood is adopted as the base floodplain management flood, most buildings, public facilities, etc. will have to be elevated or floodproofed to the 500 year flood elevation. The question is whether there are public facilities, like hospitals, water treatment plants, major transportation routes (e.g., I-80) that are so critical that they should be required to protect to the highest flood level reasonably imaginable – the Standard Project (SPF) or Probable Maximum Flood (PMF).

Flood experience shows that the estimated 500 year flood discharge has been exceeded by a factor of 2 ½ (Q_{500} x 2.5) in some areas. The '08 Cedar River flood in Cedar Rapids was only about 1 ½ feet below the projected level of the SPF as shown in a 1967 Corps report. Although there is no frequency attached to the Standard Project Flood, floods approaching this "upper limit" do, in fact occur.

The panel did not discuss in any detail what facilities would be considered "critical facilities" requiring a SPF or PMF level of protection but there seemed to be general consensus they would include what are now considered "maximum damage potential" uses as well as drinking water treatment plants and, possibly, wastewater treatment plants and major transportation routes. If such a high level of protection proved infeasible for a particular facility, a waiver or variance could be granted upon justification that the highest level of protection possible is being provided.

The two main obstacles to implementing such a high standard of protection would likely be 1) political resistance and 2) lack of SPF or PMF information – discharges, profiles and inundation maps. It might be potentially possible to develop a regional equation approach to determining SPF or PMF discharges and the profiles and inundation limits could than then easily be incorporated into any DNR-developed flood studies and the resulting maps.

Issue #3: *Levees and floodwalls are important structural measures to reduce flood damages and may be the only economical solution in addressing existing, vulnerable development. However, levees can and do fail due to overtopping or structural inadequacies and when they do, the "protected" properties often suffer sudden and catastrophic damages. The issue is whether the standard of protection for levees needs to be increased significantly before an area behind the levee is considered adequately protected and not subject to floodplain regulations and mandatory flood insurance. A related question is whether levees should be considered as meeting the flood protection requirements for new development.*

The consensus of the panel was that to be considered effective for protecting high damage potential uses, the design level of protection (i.e., top of levee) should be equivalent to the Q_{500} elevation plus freeboard.

Iowa's current floodplain development rules require that levees protecting high damage potential uses provide a minimum level of protection equivalent to the Q_{100} profile with three feet of freeboard. In addition to this minimum top-of-levee design requirement, there are geotechnical and interior drainage requirements that must be met. The Corps at one time also used the "Q_{100} plus three" as a general rule of thumb but now uses the following for top-of-levee design:

- The design level of protection is determined by the "National Economic Development" criterion that, in so many words, sets the protection level where the benefit-cost ratio is maximized. In some cases, this may result in a design flood level exceeding the 100 year flood.
- Freeboard is determined by a risk and uncertainty approach. This approach takes into consideration the relative uncertainty involved in determining discharge-frequency relationships, which can result in less or more freeboard compared to the 3 foot rule of thumb.

Aside from the questions of how the design level of protection and freeboard are determined and the technical merit of the approach, the basic question is whether a Q_{100} level of protection is adequate for levees protecting high damage potential uses like homes, businesses and industry. Assuming there's a one percent chance in any given year that a 100-year levee will be overtopped by a larger flood, there's about a one-in-four chance the levee will fail by overtopping in a 30-year period – about the same chance that a house constructed on fill at the Q_{100} flood elevation has of flooding. It would appear at first look, then, that both methods provide an equal degree of protection. But there are several important differences:

- Once a levee overtops, the area behind it rapidly fills with flood water to great depths and rescue and evacuation become difficult. The average annual flood damages for a non-elevated house behind a 100-year levee is considerably greater than a house constructed on fill at the 100 year flood level even when assuming the levee is structurally sound and will not fail before being overtopped.

- A Q_{100} level of protection with adequate freeboard does not necessarily equate to a 1% risk of flooding for the protected area. When the risks of structural failure (i.e., failure before overtopping) and interior drainage problems (e.g., pump failure) are considered, the flood damage risk of a levee-protected structure could be significantly greater than 1%.

As it now exists under Iowa's and the NFIP's policies, land behind a levee that provides a Q_{100} plus freeboard level of protection can be removed from the regulatory floodplain and any new construction or substantial improvements of existing development does not have to meet any flood protection requirements. Nor is flood insurance required as a condition of federal financial assistance or a mortgage from any federally insured or regulated lending institution.

If a 500 year flood is adopted as the base flood for floodplain management purposes, it necessarily follows that levees protecting high damage potential uses would have to provide a Q_{500} plus freeboard level of protection to be considered as providing effective protection. The panel felt freeboard using a risk and uncertainty approach was appropriate for determining the top-of-levee design profile rather that the more arbitrary 3 foot rule of thumb. Although a SPF level of protection requirement was discussed, there were no strong arguments presented for such a minimum level of protection for levees.

A 500 year levee standard could have ramifications as to whether the Corps could participate in constructing new local protection works. If, for instance, the Corps determined the NED criterion resulted in proposed levee with a 100 year level of protection, the local sponsor would have to pay the increased cost of construction to provide the 500 year level of protection required. This could be a significant cost that might preclude the required local participation.

An implementation issue of perhaps greater concern is how the 500 year standard would be applied to existing levees that only provide 100 year flood protection. In the wake of Katrina, FEMA is already requiring communities to certify that their levees provide the required level of protection if their current NFIP map shows the area behind the levee as not being within the 100 year floodplain. It's not known whether FEMA would defer to a state's requirement for levee certification (e.g., use a state-required 500-year level of protection for levee certification instead of a 100-year standard) but any new or substantially improved high damage potential structures behind a 100 year levee would not be considered as having adequate protection under state law unless it were elevated or protected to the appropriate level. And, state law would take precedence over any NFIP requirements. An alternative might be to just apply the 500-year standard to newly-constructed or rehabbed levees that protect high damage potential uses but this would also raise a number of potential problems and issues. Also, would any Iowa-generated flood maps show such an area to be within or outside the regulatory floodplain?

The panel did not discuss to any degree the issue of whether a flood control levee should be an acceptable method of providing flood protection for new development. Fill is the predominate method of meeting flood protection requirements for new development. Levees are rarely (if ever) used for this purpose because of the need for up-front planning and design, geotechnical investigations, interior drainage requirements, maintenance, etc. Additionally, it's relatively easy to get development-on-fill exempted from flood insurance purchase requirements compared to a levee certification process.

Issue #4: *Should the "one foot rise" standard be changed to a one-tenth foot or zero-rise standard*? *Iowa and a handful of other states pioneered the floodway – floodway fringe concept of managing floodplain development, with the floodway boundaries being delineated based on a one foot rise for the 100 year flood. This effectively allows a significant portion of the floodplain to be developed. A more stringent standard would effectively reduce the developable portion of the floodplain to "non-effective flow areas".*

The panel's consensus was that Iowa should continue to use the present one foot rise criterion for delineating the floodway (i.e., that Iowa <u>not</u> adopt a zero, 0.1 or 0.5 ft rise standard), but that the one foot rise be applied to the Q_{500} discharge instead of the Q_{100}.

Iowa's current floodplain development regulations stipulate that the floodway boundaries be delineated based on a maximum 1.0 ft. rise for the Q_{100} discharge using a proportional conveyance reduction approach. Additionally, Iowa law requires that in establishing the floodway limits, existing development be excluded from the floodway to the extent possible and that the allowable rise be minimized. This approach is generally consistent with NFIP requirements.

Some states like Wisconsin, Minnesota, and Illinois have adopted a more stringent standard (e.g., a 0.1 ft rise floodway). This effectively widens the floodway such that only a relatively small

portion of the floodplain can be developed. There was no support expressed by the panel members for a more stringent standard. However, the consensus was that the existing standard be applied using the 500-year flood and this could result in a wider floodway.

There are a number of communities that have floodways established on a one foot rise for the 100-year flood standard. An important implementation issue is whether these established floodways should remain "as is".

Issue #5: *Should the inundation limits of a Standard Project Flood or flood of a similar magnitude be shown on all flood maps? At best, the floodplain maps produced under the NFIP show the 100 and 500 year floodplains and many of the maps only show the 100 year floodplain. Thus, the maps do not provide any information as to what is potentially possible.*

The panel's consensus is that the inundation limits of the Standard Project Flood or similar "upper limit" type of flood be provided on all flood maps for information purposes.

At one time, the Corps routinely determined the magnitude of a Standard Project Flood (SPF) and mapped its inundation limits along with the Intermediate Regional Flood (i.e., the 1% exceedance probability flood) as part their Floodplain Information Reports. With creation of the NFIP in 1968, the role of providing floodplain mapping largely become the responsibility of the Federal Insurance Administration and the practice of determining and mapping the SPF for information purposes fell by the wayside. The initial Flood Hazard Boundary Maps produced for the NFIP only purported to show the 100 year floodplain, as the NFIP regulatory requirements only pertain to the 100 year floodplain. The mandatory flood insurance purchase requirements, which were put in place in 1973, also only pertain to the 100 year floodplain.

Detailed Flood Insurance Studies at one time included discharges and profiles for the 25, 50, 100 and 500 year floods and the study maps showed both the 100 year and 500 year flood inundation limits. In recent years, however, FEMA has gone to a policy of only determining and mapping the 100 year flood. Thus, any new detailed studies likely will not include the 500 year profile and inundation limits even though computation of such is not a significant study expense.

There are relatively few places in Iowa where there is information showing what is potentially possible. Corps Floodplain Information Studies were prepared for relatively few cities and even when such information is available, it has largely been forgotten (e.g., Cedar Rapids) and is not shown on the current NFIP maps. The panel felt that such information should be developed as part of all flood studies and shown on flood maps for information purposes. If a SPF-level of protection were required for critical facilities as discussed above, such information would be required to effectively administer this level of protection requirement.

Issue #6: *Should mandatory flood insurance purchase be expanded beyond the 100 year floodplain to include areas behind levees, the 500 year floodplain, etc.*

The panel made no strong argument for changing the current flood insurance purchase requirement.

In 1973, Congress changed the NFIP legislation to require flood insurance as a condition of receiving any federal assistance or a loan from a federally-regulated or insured lending institution for a building if the building was in a "special flood hazard area", i.e., the 100 year floodplain as identified by NFIP flood maps. The main reason for this change was that most people did not voluntarily purchase flood insurance even when a community had joined the NFIP and made flood insurance available to everyone in the community, regardless of location and flood risk.

Experience in Iowa and other states has shown that the existing requirement for flood insurance purchase has not resulted in anything near full coverage for all the buildings within the delineated 100 year floodplain. And almost no one outside the 100 year floodplain purchases flood insurance. As a result, much of the flood damage to buildings that occurred in 2008 was not covered by insurance and there now is a significant demand for public assistance to repair and rebuild buildings that could have been insured against flood losses.

A strong argument could be made that any insurable structures within the floodplain – the area that could be flooded by a flood of a Standard Project Flood magnitude – should be required to purchase flood insurance. If the rates were truly based on risk, the cost of flood insurance for structures outside the 100 year floodplain, behind 100 year levees, etc., would be relatively cheap. However, the panel did not recommend a policy change of expanding the mandatory purchase requirements as they currently exist under the NFIP.

Issue #7: *At one time, the Iowa Legislature vested the responsibility for floodplain management, as well as other water functions, in a single organization. Today, these responsibilities are spread among various entities. The issue is whether Iowa should redefine or reestablish a single entity as having overall responsibility for floodplain management.*

The panel felt that, yes, some type of policy-oriented body should be created to focus more attention on Iowa's flood problems and advancing solutions to reduce flood damages.

The General Assembly in 1949 created the Iowa Natural Resources Council and charged it with significant floodplain management duties, up to and including the design and construction of flood control works. Significant amendments in 1957 and 1965 further expanded its authority and duties, including the responsibility to regulate floodplain development.

In its early years, the Council and its staff became a national leader in floodplain management. The nine-member Council had only two major programmatic responsibilities, floodplain management and water allocation, and devoted much of their time to floodplain management issues.

With the merger of state agencies in 1983 and again in 1986, the Council's floodplain management responsibilities were transferred and now rest with the Environmental Protection Commission. However, the EPC has very broad responsibilities and floodplain management receives almost none of the Commission's attention or consideration. Once a major part of a single agency, Iowa's floodplain management program is now only part of a section within a bureau within a division within a department. Additionally, funding for the program has continued to decline.

To provide a much sharper focus on Iowa's flood problems and potential solutions, the panel felt that some type of policy or advisory body should be created whose primary responsibility would be to deal with flood issues. This would give Iowa's floodplain management program more visibility and could be an advocate for adequate funding. The panel did not reach any consensus whether this body should be purely advisory in nature or whether it should have policy-making authority. Nor did it reach any consensus on whether such a body should operate within the organizational confines of the DNR or any other state department or be a "stand alone" independent body. However, it was felt that at least some members of this body should have some degree of expertise in hydrology and hydraulics. The old Iowa Natural Resources Council, for instance, often had members who were professors of hydraulics and civil engineering. Additionally, the State Geologist served as an ex officio member and the Chief of the Iowa District of the USGS often attended the meetings.

Although the panel did not reach any consensus on the makeup or organizational structure of such a body, it did discuss various approaches that might be considered. These include the following:

- Create an advisory panel within the organizational structure of DNR. Such a panel would be advisory in nature; any recommendations for policy changes would have to go through the EPC.
- Create a flood policy council or commission with independent policy authority and supporting staff (essentially re-creating the old INRC as an independent agency).
- Shift much of the DNR's floodplain management authority and responsibilities to Homeland Security and create some type of advisory panel there under if such does not currently exist.
- Create an advisory panel as a stand-alone entity to advise the DNR, Homeland Security, IDALs, the Governor's office, etc. on state flood policy.

The role of the newly-created Rebuild Iowa Advisory Commission and the associated Rebuild Iowa Office was discussed as to how its responsibilities might fit into this recommendation, but panel members did not know if this would be a continuing entity or what its long-term responsibilities might be. It was noted that neither the RIAC members nor the present RIO staff had any significant expertise in floodplain management or hydrology in general.

Issue #8: *Crops are considered a low damage potential use of the floodplain and as such are not regulated under most floodplain management regulations. Yet, agricultural damages account for a large part of Iowa's flood damages. Even for crop damage that is covered by crop insurance, there is a significant federal subsidy. Should agricultural crops continue to be considered low damage potential uses with no consideration of the frequency and public costs of flood damage thereto?*

Although the panel discussed the issue of crops in the floodplain and whether damage to such should be lumped into "flood damages" with damages to buildings and infrastructure, the panel did not make any specific recommendations regarding the use of floodplain for crop production.

Crops are generally considered an acceptable use for the floodplain as they generally do not obstruct flood flows to any major extent (especially as compared to woody plant growth like trees and brush that remain upright) and result in relatively low damages on an per-acre basis compared to buildings and other infrastructure. Nonetheless, the total crop damage can be significant when many acres are inundated.

The legal rationale that justifies regulating floodplain development is the public costs of flooding – things like the demand for flood protection works and disaster relief. In general, crop damages are not sufficient to economically justify a federal flood protection project such as a levee and there are relatively few federally-designed and constructed levees protecting crop ground. The Corps does provide levee repair assistance under their PL99 program, but relatively few agricultural levees are in the PL99 program. And the costs of any agricultural levees constructed under the authority of Iowa Code Chapter 468 (Levee and Drainage Districts) are paid exclusively by the landowners that benefit. There is a federal subsidy for federal crop insurance, but the insurance covers all hazards and it is difficult to separate out flood losses from wind, hail, upland drainage problems, etc. and the extent to which federal dollars subsidize any flood losses to crops. In general, the public costs of flooded crops are relatively minor compared to other flood loss and regulations of some nature to restrict cropping of the floodplain might raise due process issues.

After the floods of 1993 and 2008, there was considerable interest in easements or outright purchase of damaged crop ground. While such payments might be construed to be a flood cost,

the public receives benefits such as wildlife habitat even when the land remains in private hands, as is the case with easements.

If there is an issue regarding crop damage, it is that crop damage may often be lumped into overall flood damages, thus providing a skewed picture of flood damages in Iowa versus the rest of the nation due to the fact that about 90 percent of the land is devoted to agriculture with nearly two-thirds in intensive row crops. . A number of persons over the last decade or so have pointed to Iowa as leading the nation in flood losses, which leaves the impression that Iowa does little to control floodplain development. Very large floods and a relatively low level of funding for Iowa's floodplain management program have no doubt had their impact, but Iowa was one of the first states in the nation to have state-level floodplain management regulations and in many ways has been a national leader. There has not been a consistent, long term method of determining flood losses so loss figures are often suspect.

Issue #9: *Aside from the issue of whether the 100 year flood should remain the standard for floodplain management, the question is whether the current, nationally-accepted methods of calculating the 100 year and other recurrence interval floods are underestimating discharges or overestimating the recurrence interval (e.g., is the calculated 100 year flood discharge actually a 50 or 25 year flood discharge?). A related question is whether we are seeing a trend of increasing discharges. The determination of frequency – discharge relationships is at best an estimate but can we decrease the error of estimate or at least better quantify the confidence or uncertainty in these estimates?*

The panel felt the current methods of determining discharges (e.g., log Pearson Type III) are appropriate. While improvements to the methodology will continue to be made, there is no urgent need for new, wholly different methods. Instead, more emphasis needs to be placed on the uncertainty involved in calculating flood discharges to give the lay public as well as design professionals a better understanding of risk and uncertainty. With regard to any trend to increasing annual peak discharges, there currently is no strong evidence that such is the case.

Since the late 1960's, the log Pearson Type III (LP3) distribution has been the de facto standard for defining discharge-frequency relationships at sites where there is a continuous record of annual peaks. Most regional equation approaches are also based on LP3-generated data for gaged sites. Bulletins 15, 17, 17A and 17B (1981) all recommended the use of LP3; with each successive publication providing more guidance as how to handle various types of records and regional skew weighting. There likely will be a Bulletin 17C that provides further modifications of a "fine tuning" nature rather than fundamental changes in methodology. One of the changes that could appreciably affect the rarer events is a new regional skew analysis, especially at the shorter-record stations.

The panel felt that more emphasis needs to be placed on the uncertainty involved in determining flood discharge-frequency relationships and suggested that confidence limits routinely be provided to give laypersons as well as design professionals a better sense of the "looseness" of estimates.

Notwithstanding the technical merit of using the LP3 distribution to define flood frequency relationships, the issue of non-stationarity must be addressed. Climate change is the issue most often highlighted, as climate change could significantly increase (or decrease) annual peak flows by altering precipitation amounts and distribution. If significant changes are resulting in a non-homogenous record of peak flows, neither LP3 nor any other similar technique can be expected to provide an accurate picture of flood risk. There is some research taking place as to how non-stationarity should be addressed but there currently are no mainstream applications available.

Several of the panel members independently arrived at a similar conclusion: there currently is no strong evidence that annual peak discharges across Iowa are trending higher due land use

changes, climate change, or other factors. While there is some evidence the average annual flow (i.e., total annual volume) is increasing, this increased flow has not been manifest in higher annual peaks.

Issue #10: *A number of laypersons as well as some hydrologists feel the frequency and magnitude of floods in Iowa are increasing. Some attribute this increase in flooding to landscape changes rather than increases in the frequency and magnitude of precipitation, or at least feel land use changes have played a major role. The issue is if landscape changes such as tile drainage, increased row cropping, and urbanization have significantly increased the frequency and severity of flooding and, if so, whether landscape "restoration" can be used to reduce the frequency and severity of floods.*

The panel acknowledged that land use changes can have an effect on flood discharges for the more frequent events on smaller basins but generally have relatively little or no effect on the more rare events on the larger streams and rivers. For the 2008 floods, significant amounts of rainfall over a long period of time completely saturated the soil and filled depressional areas. When the critical rains came in early June, there was little infiltration capacity left.

Most studies to assess the effects of land use changes on the frequency and magnitudes of flooding have come to the conclusion that they have relatively little effect on the magnitude of the rarer events on the larger streams and rivers. Very large floods occurred well before significant land use changes occurred in Iowa. Yet, this issue continues to arise after every major flood event. The panel did feel, however, that a more definitive, thorough analysis of this issue was needed. Selection of a model or particular approach could be problematic as many of the large-basin models do not have the spatial and temporal fineness to assess field-scale changes while many of the smaller field-scale models cannot assess the effects of any localized changes on overall basin hydrology.

Issue #11: *Should the concept of a "perfect storm" flood be revisited as to the techniques used to estimate the maximum flood that could reasonably be expected for a particular region? Aside from the issue of whether all flood maps should show the inundation limits of what is potentially possible, the issue is how such a flood should be calculated.*

The panel felt a regional approach to determining an "upper limit" type of flood was possible by using a combination of previously-determined Corps Standard Project Floods (SPF) along with an envelope curve approach, thereby avoiding the necessity of constructing a rainfall-runoff model for each and every flood study/map.

The panel previously concluded that a flood of the SPF magnitude should be determined and included on every flood map. At one time, the Corps routinely calculated the magnitude of a SPF for each and every floodplain information report it did. But with the NFIP mapping effort beginning in the early 1970's, this information has not been generated for most locations. Unlike the stochastic approach inherent in determining the 25, 50, 100 and 500-year recurrence interval floods where the annual peaks are analyzed, generation of the SPF involves a basin rainfall-runoff model. Therefore, determining such a flood for floodplain mapping could involve a significant, additional effort above and beyond the typical study effort.

A plot of previously-determined SPFs suggests that a regional equation approach may be justified. A plot of SPF magnitudes versus drainage areas for Region 2 (as per WRIR 00-4233) resulted in a relatively good fit for the equation $Q_{SPF} = 5141 \times DA^{0.408}$. Comparing this equation with the one-variable regional equations, a general rule of thumb is that the SPF is about 3 times the Q_{100} and two times the Q_{500} discharge. Additionally, comparison of the SPF with a envelope curve (updated to reflect '08) shows that as time goes on, the envelope curve of experienced

Iowa floods lies in the SPF region. More work is needed but it appears feasible to determine this "upper limit" of flooding without developing rainfall-runoff models for each and every study site.

Issue #12: *Are the stage – discharge relationships in Iowa's rivers shifting upward? Some have suggested Iowa's rivers are "filling in" thereby increasing flood severity independent of any increased flood frequency or magnitude. There is empirical evidence for this in several locations (e.g., Iowa River at Marshalltown) but is this a widespread condition as some have alleged? This is a significant issue that needs to be addressed.*

The panel acknowledged that there are areas where the stage-discharge relationship is changing but these are somewhat limited to geographical regions (e.g., western Iowa stream degradation) or specific locations (e.g., Marshalltown aggradation). Significant changes were not perceived to be a widespread, statewide problem. Further research into this issue may be justified but the panel did not place a high priority on it.

Issue #13: *The acquisition of statewide LIDAR will potentially make it possible to generate high-quality floodplain maps for virtually all areas in the state. Also, the flood maps could be linked to the NWS' flood forecasting center to provide near real time inundation maps. This will take a significant level of resources committed over a period of time. First, however, there are a number of technical issues that need to be identified and addressed before this can become reality.*

The availability of LIDAR-generated topographic presents a unique opportunity to produce high-quality floodplain maps for the entire state and to incorporate much-needed floodplain information such as "perfect storm" inundation limits, digital "real time" mapping, etc. into the process. However, the panel strongly recommended that any large-scale effort be preceded by a pilot project of at least a year to address various technical issues.

The past approach to producing paper maps is fairly well known. With the digital age, there are a variety of new approaches that can be incorporated into the mapping process that will yield dividends in the long run. However, many technical issues are yet to be addressed or resolved, ranging from how to calculate the "perfect storm" discharge, the best model to use, storage and dissemination the flood data, coordination with FEMA, etc. A pilot project would allow the time to identify and resolve these issues. A group with a variety of backgrounds including hydrology and GIS applications should guide this pilot project and provide recommendations for any larger, ongoing effort.

Issue #14: *One of the often-heard comments after a major flood is that flood insurance is too expensive. The issue is whether flood insurance rates reflect the actual flood damage risk or if the lower risk policy holders subsidize the higher risk policy holders and to what extent NFIP administrative functions like mapping increase policy rates.. An analysis of the rates versus damage risk might dispel many of the myths about flood risks.*

In general, the panel felt the existing rate structure for flood insurance was not reflective of the actual risk, especially for post-FRIM construction or structures located outside the 100-year floodplain. For several of situations reviewed by the panel, it appeared that the rates were much higher than needed to be actuarial sound. However, a more in-depth, nationwide analysis of rates v. risk is warranted. Unless this issue is addressed, it is unlikely that voluntary coverage will increase substantially over the next decades.

Issue #15: *The DNR has an implicit, if not explicit, duty to inspect dams and levees to insure they are structurally sound and provide the required degree of protection. Yet, there is no systematic evaluation of these structures. Both FEMA and the Corps have some responsibility for some flood control works but FEMA rarely inspects structures and, other than those directly under their control, the Corps' only has a limited inspection program for levees and rarely inspects dams. The issue is whether the state should have an inspection program, who should do it, and how can it be funded?*

The panel felt the DNR's existing dam inspection needed to be continued and strengthened but did not feel a significant, state-level levee inspection program was needed at this time.

Currently, the DNR attempts to inspect all high hazard and relatively large dams on a two to five year rotation. This is a relatively small part of the more than 3000 dams the DNR has jurisdiction over; the remainder only receive inspections on an as needed-basis. In recent years the success of the DNR's dam inspection program has been tied to FEMA dam safety funds and these funds are decreasing. The current program (inspecting high hazard and large dams every two to five years) should be considered a minimum level of effort and should be maintained if not enlarged.

Corps-designed and constructed levees are typically turned over to the local sponsor for maintenance. However, the Corps has an active inspection program to insure the local sponsor does, in fact, maintain the levees. The Corps also inspects levees under their PL99 program, as levee systems have to meet certain standards to be eligible for PL99 repair funding.

Some levees like the Birdland levee in the Des Moines area received much attention during the '93 and '08 floods, but these are somewhat atypical as they were not originally constructed by the Corps. Additionally, the structural problems with these levees were not unknown, especially after the '93 floods.

If there is a need for a levee inspection program at the state level, it would be to cover any levees that are currently considered as providing 100 year or greater flood protection but do not have any regular inspection by the Corps. Under FEMA's post-Katrina levee certification process, any such levee systems that have "fallen through the cracks" should be identified and the DNR should take the responsibility to provide the needed inspections. The DNR currently has the statutory authority to conduct the inspections and to order any necessary remedial work but it is expected the number of levees needing such will be very small. Thus, this should not be a major undertaking that will require a significant level of effort.

Issue #16: *The floods of '93 and '08 brought it to the public's attention but the story is the same for all floods: people simply do not willingly purchase flood insurance and many within the 100 year floodplain as well as the 500 year floodplain had no flood insurance. One of the reasons for this is misinformation (e.g., my agent says I can't buy flood insurance because I'm in the floodplain) or lack of recognition of the real risk. The issue is whether we can do a better job of informing people of the true flood risk and prompt a greater degree of voluntary flood insurance.*

Everyone agrees on the need to provide better information on floods and risk; the issue is one of how this is best done. The panel felt this issue needed to be approached from various angles; no single approach would succeed. Among the approaches discussed was better education for professionals in the banking and insurance industries, including mandatory requirements for professional licensing and local community efforts such as placing messages on door handles (e.g., you have a 1 in 4 chance of flooding over the next 30 years), as well as statewide marketing efforts. Additionally, it may one day be possible to click on a house or building and get an individualized risk assessment (LIDAR paired with site-specific flood information. Also important, as discussed above, is the cost of flood insurance relative to the risk.